EXHAUSTIVE MINING.

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The mineral resources of the State of Ohio are important element of its wealth, of which the coal measures form no small factor.

The geologists inform us that about one-fourth of the State, or 10,000 square miles, is underlaid with coal-bearing strata. These, for convenience, have been divided into three series, viz:

The Lower Measures.

The Barren Measures.

The Upper Measures.

These are each about 500 feet in vertical section. Our coal is

produced from the Lower and Upper Measures.

The Barren Measures embrace that part of the vertical section lying between the *top* of the Upper Freeport and the *bottom* of the Pittsburgh seams of coal, and, as the name indicates, contains but little coal of minable thickness.

The names and order of the coals in the Lower Measures are as follows: (Vol. V, Geology of Ohio, page 127.)

Coal seams of the Lower Coal Measures of Ohio.

12. Upper Freeport coal.	Coal No. 6 and Coal No. 7.	Big Vein of Salineville, Dell Roy seam, Cambridge. Alexander, Bayley's Run, Norris, Happy Hollow, Waterloo.
11. Lower Freeport Coal (Upper Kittanning C'l.)	Coal No. 5 and Coal No. 6 a.	Roger, Steubenville shaft, Hamden Furnace, Hatcher.
10. Middle Kittanning (No 5 a coal.)	Coal No. 6 and Coal No 4.	Strip vein of Hammondsville. Osnaburg, Pike Run, Dennison, Coshocton Zanesville, Straitsville, Nelsonville, Carbondale. Sheridan.
9. Lower Kittanning coal,	Coal No 5, Coal No 4, Coal No 3	Leetonia, Mineral Point, New Castle, Lower New Lexington, Creek Vein, Hammondsville.
8. Upper Clarion coal;	Scrub Grass coal No 4 b, Coal No 4, Coal No 3.	Canfield cannel, Creek vein, New Lisbon, Limestone coal of Vinton county, etc.
7. Lower Clarion coal;	Coal No 4 a.	
6. Brookville coal;	Coal No. 4	Grey limestone coal of Stark Co, Evansdale, Greentown, etc.
5 Tionesta coal;	Coal No 3 b	Bolivar, McArthur, (Newland's) Vinton Furnace.(?)
4 Upper Mercer coal;	Coal No 3 a	Bryce coal of Canfield, Bedford cannel, Coshocton county.
3 Lower Mercer coal;	Coal No 3.	Blue limestone coal, Wick & McDowell's coal of Canfield, Flint Ridge cannel
2. Quakertown coal;	Coal No 2	Wellston (?)
1. Sharon coal;	Coal No 1.	Block coal, Brier Hill, Youngstown, Massillon, Jackson shaft (?)

The adoption by Professor Orton of the Pennsylvania names for the Ohio coals will for a time be a source of confusion, (and so would any other system.) Coal men will cling to the local names, partly from attachment, but more particularly for the advertising.

I would have preferred a new system of numbering, from the fact that it locates the seam in the vertical section better than by names. Professor Orton has given in the table above all the synonyms, and in the Hocking Valley, (and it is to this Region I wish to confine my remarks) we can call the seam which is almost ex-

clusively worked, the No. 10, Middle Kittanning, old No. 6, Straitsville or Nelsonville seam.

Professor Orton says in regard to the acreage of the Hocking Valley field: *

"Various estimates have been made of the areas that contain the thick coal of the Hocking Valley.

"Read estimates the field to be equal to 100,000 acres of 10 feet coal. (Vol. III, page 648.)

"Hunt assigns an area of about 250 square miles or 160,000 acres to the field without specifying the thickness of the coal contained.

* * * * * * * *

"Counting the Ohio Central Railway as the eastern boundary of the thick coal, and the north line of Athens township as the southern boundary, and balancing the many faulty regions within the field against the known extensions of the seam beyond the limits taken, we find the areas of the coal 5 feet and upwards in thickness, to make an aggregate of 94,156.8 acres, or 147.12 square miles. Some reduction from these figures will be required in accounting for the coal already mined in the Valley. * * * * In addition to the coal of the great seam, there are several other sources of coal supply within the district. The Lower Kittanning coal is occasionally mined on a small scale, as is also the Lower Freeport seam, while the Upper Freeport coal here becomes the basis of large mining operations."

Professor Orton divides the Hocking Valley into four divisions, as follows:

The Sunday Creek Valley;

The Shawnee and Straitsville District;

The Monday Creek Valley;

The Hocking Valley proper.

He describes each district by boundaries, and gives sections of the coal seam showing the peculiar characteristics in each district. Vol. V of the Geological Report abounds in facts gleaned only by patient and arduous labor, and is a valuable contribution to the scientific knowledge of our mineral resources.

Of the 94,000 acres of coal of 5 feet and upwards in thickness, estimated for the Hocking Valley region, I assume that "The Monday Creek Valley," "The Hocking Valley proper," one-half of "the

*Volume V, Geology of Ohio, page 917.

Shawnee and Straitsville District," and the western portion of "the Sunday Creek Valley," in Townships of Trimble and Dover, in all comprising at least one half or 47,000 acres, is directly connected by shipping facilities with the Columbus, Hocking Valley and Toledo Railway, and the Railway Company owns in fee simple about one-sixth of this amount. This fact has directed my attention to the wasteful method of mining, and it is with the hope of awakening an interest in the matter, that I have prepared this paper.

This coal field is exceptionally favorable for cheap and systematic mining. The floor of mines is comparatively level, the usual dip, except in local cases, being 25 to 30 feet to the mile, about south 65 or 70 degrees East. The seam is of unusual thickness, is free from all dangerous gases, has a good roof, is easy of drainage, and has, in short, extraordinary advantages in favor of the owner, operator and the miner; to the owner in the large amount of coal obtainable from an acre; to the operator in the less cost for "dead work;" to the miner in the less amount of hard labor in "bearing in."

How is this valuable coal deposit being developed? Are either of these parties reaping the benefits which they should receive?

Let us determine, if we can, how much coal there is within this 47,000 acres. The seam varies from 5 to 11 feet in thickness, but not all of the vein is good coal. Let us first ascertain the percentage of coal to the vein space, using the following coal sections given by Professor Orton,* for which I have computed the percentage of coal and slate. These sections extend over the territory, and will give an approximate average:

Height of Seam.		Name of Mine.		Percentage of Coal.	Slate
Ft.	In.				
10	0	C. & H. C. & I. Co.,	No. 5.	91.7	08.3
10	7	Do.	" 35	90.0	10.0
9	6	Do.	" 9	80.7	19.3
8	6½	Do.	" 13	88.8	11.2
9	4½	Do.	" 15	86.2	13.8
6	10½	Do.	" 17	87.3	12.7
6	9	Do.	" 23	92.5	07.5
6	9	Do.	" 29	88.8	11.2
5	6½	Haydens,		81.2	18.8
6	6	Johnson Bros. & Patterson's		94.9	05.1
7	0	Floodwood		87.5	12.5
5	1	Hamley Run		88.5	11.5
12) 92	6			12) 1058.1	141.9
7	8½			88.17	11.83

*Volume V, Geology of Ohio, page 954.

Or an average for the twelve sections of

Height of seam	7ft 8½in.
Percentage of coal	88
" " slate	12

I think 7 feet 8½ inches is too great for an average of the whole field, and would assume six (6) feet of coal, which, being 88 per cent. of vein space would give 6.82 feet (6 ft. 10 in.) for an average height of seam. Multiply 43,560 (the number of square feet in an acre) by 6.82, gives 297,079 cubic feet of vein space per acre. By previous investigation I have found that in practice thirty-seven (37) cubic feet of space mined will yield one ton of *lump coal.* Dividing, then, 297,079 by 37 gives 8,029 tons of *lump coal* per acre.

In order to ascertain the proportion of lump, nut, pea and slack, I have, through the courtesy of the Columbus and Hocking Coal and Iron Company, and the Ohio Coal Exchange, had access to their books showing a year's work in mining. The lump and nut is all shipped, but not all the mines make pea, and but little slack is ever shipped. It is not possible, therefore, to get the exact proportion; but from the results obtained from those who make pea, from conversation with observing superintendents, and from my own observations, I conclude that the pea and slack are equal, and that both together equal the nut. Assuming this proportion, I obtain the following table; the first column contains percentages of *all* the coal; the second shows the percentages of those mines making *pea*, and omits the slack, which is usually thrown away; the third shows percentages of those mines which make no *pea*, confining their work to *lump* and *nut*, and throwing away both the pea and slack:

Lump coal,	76	81	86½
Nut "	12	13	13½
Pea "	6	6	---
Slack "	6	---	---
	100	100	100

These figures are based on the use of screens with 1¼ inch space between bars for lump coal; ⅝ inch for nut, and ⅜ inch for pea, and are believed to be very near the truth.

Let us now compute the amount of coal per acre. Using the lump coal as 76 per cent., we find the other items to be as follows, in tons of 2,000 pounds.

	Per Cent.	Tons.
Lump coal,	76	8,029
Nut "	12	1,268
Pea "	6	634
Slack "	6	634
	100	10,565

I have all also computed the tonnage per acre by the method of specific gravity. Assuming as does Professor Orton,* the specific gravity of our coal to be 1.29 (ranges from 1.24 to 1.34) there will be 1,752 tons per acre per foot in height, and for our 6 feet of coal (vein space 6.82 ft.) there will be six times 1,752, equals 10,512 tons. Comparing these results, and using the percentages above obtained, we have:

Method of 37 cu ft vein space.	Per Cent	Method of specific gravity, 1.29
8029 tons,	Lump 76	7989 tons.
1268 "	Nut 12	1261 "
634 "	Pea 6	631 "
634 "	Slack 6	631 "
10565 tons.	100	10512 tons.

This agreement is remarkably close, and we find that if we use 88 per cent. of space mined as being equal to the *coal*, or 37 cubic feet of space mined as equal to one(1)ton of *lump coal* we are not far from the truth. This percentage of lump coal is better than that given by Professor Orton for the State, who gives only 66 per cent., while we find 76 per cent.

How much of this 10,500 tons of coal per acre shall we be content with saving?

The rule which allows 1,000 tons per acre for each foot in height will only account for 6,000 tons.

Do we consider this good mining, and shall we be satisfied with such a result? Hon. Andrew Roy, ex-State Mine Inspector, informed me about two years since, that in his opinion not over *one-half* the coal had been won in mines opened in the Hocking Valley region, but that improved methods had been adopted, which were giving better results.

Professor Orton says: "The best practice that is fairly well verified in Ohio gains *two-thirds* of the coal, and the cases in which this is done are very rare. More than this is claimed in many mines, but it is probable that, if examined, such claims would be found untenable."

*Volume V, Geology of Ohio, page 155.

If only 50 to 66 per cent of the coal is being saved, it is surely time for the owners of this valuable coal property to open their eyes and bestir themselves to secure better resslts.

Who is to blame for this state of affairs? I answer, the owner himself, in that he knows nothing of the underground workings, and seems to care less if the knowledge is likely to cost him a dollar at present. The law makers have tried to turn him into the right path, but few have complied with the law in regard to maps of mines. I think it is such a wise measure that I quote Section 296 of the mining law:

SEC. 296. The owner or agent of any mine having an excavation of not less than fifteen thousand cubic yards, shall make, or cause to be made, an accurate map or plan of the working of such mine on a scale of not less than two hundred feet to the inch, showing the area mined or excavated, and the location and connection with such excavation of the mine, of the lines of all adjoining lands, and the name or names of each owner or owners, so far as known,marked on each tract,and the owner or agent shall annually thereafter make, or cause to be made, an addition to said map, showing the progress and plan of the working of such mine during the previous year up to the date of survey; provided, that said additions shall be made semi-annually whenever the mine inspector deems it necessary and so directs. The map shall be kept at the office of such mine, and open to the inspection of the mine inspector, or his assistants, at all reasonable times, and at the request of the inspector the owner or agent shall file a correct copy of such map with said mine inspector at Columbus, and in case of refusal on part of the owner or agent to make and file such map, the inspector is authorized and required hereby to cause such map or maps to be made in duplicate, at the expense of said owner or agent, the cost of which shall be recoverable against the owner or agent in the name of the State mine inspector; and in case of refusal by said owner or agent to make, or cause such map and the additions thereto to be made, for sixty days after notice by the mine inspector, said agent or owner shall be liable to a fine of five dollars for each and every day until said map is made, which shall be collected in the name of the State of Ohio, at the suit of the State mine inspector, and the amount so recovered shall be paid into the township school fund of the township when collected. And when any mine is exhausted or abandoned, and before the pillars are

drawn in any portion of the mine, the owner or agent thereof shall cause to made a correct map of such mine, showing the area and working of the same to the day of abandoning, or of drawing pillars for the purpose of abandoning, and file such map within ninety days thereafter at the office of the county recorder in the county where such mine is located; said map shall have attached thereto the sworn certificate of the mining engineer making the map, and of the mine boss in charge of the underground workings of said mine; such map shall be properly labeled and filed by the recorder, and be preserved as a part of the records of the land on which such mines are located, and the Recorder shall receive for such filing from said owner or agent a fee of fifty cents.

How many owners have complied, or could comply, with the provisions as to abandon mines, as to filing a plat with the Recorder? I assert without fear of contradiction that there is not one plat on file with the Recorders of Athens, Hocking or Perry counties.

If the cover could be taken from these hidden workings, exposing them to view, (and that is what an accurate map does) it would bring to light some bad management, which, even the owner—not claiming to know anything about mining—could see. The fear of exposure is one reason why many bank bosses do not want any surveying done or any maps made. They insist that it is not neccesary, that they can do all that is required with a compass themselves, and *save the expense*, wnich would be incurred by employing an engineer to do the work and show the exact condition of things. He may have a hundred reasons, but when he mentions the *saving of expense*, the other ninety-nine are unnecessary; that one is sufficient. Many of the bank bosses may be competent to do all that would be required, but they have not the time; their other duties keep them so busy that unless the matter is absolutely necessary, they will neglect to keep up the map of the workings. They understand the condition of things. and as long as they continue in their position, think they do not need it for themselves; but suppose they should die, resign or be removed. The old workings have, in many instances, fallen in, and it is impossible for a new man to understand the old workings, so he abandons them and directs his attention to that portion of the mine which has not been touched, leaving in many instances acres of coal that might have been, or should have been wrought. What, then, is necessary

to secure exhaustive mining?

First, an accurate map of the tract of land, showing the outcrop of the coal, the location of the streams, valleys, ridges and all objects of interest. Mr. R. S. Weitzell has described a map of this kind in the March number of this maagzine. Upon such a map, after a thorough study of the tract, the underground workings should be laid out with some system as regards the location of entries, the dimensions of rooms and width of pillars, as well as the system of ventilation, Monthly as the work advances, it should be shown upon the map in such a manner that the owner may see by inspection how much space has been worked over, in what portion the work has been done, and how much coal has been left standing in the shape of pillars, etc.; that the bank boss may he enabled to carry on his work understandingly, with safety and economy; that he may protect the mine when under streams, from falls which might be a source of great damage on account of flooding. Levels should be run through the mine to ascertain the direction of the dip, and to locate the low places for "sumps," in order to reduce the haulage of water. The amount of space excavated should also be taken in order to compare with the weights of coal returned and the percentage of the various qualities kept, to know whether any of the coal is being thrown into "gob." This information—and there can not be too much of it—will cost something, but it will repay the outlay many times.

The "double entry" system is generally conceded to be the best plan for working the coal in the Hocking Valley. But in using this system, pillars should be left of sufficient thickness to secure the safety of the mine in the advancing work, and which should be drawn when rooms are completely worked out. One great source of loss of the coal heretofore, in my opinion, has been the narrow pillars, which have not been drawn but left in the mine, not only losing the coal in the pillars, but in many cases they have been crushed, leaving an amount of solid coal in their rear, which could not be recovered. Some of the largest operators in the Valley have made a radical change in the matter, and are now leaving as much pillar as they have room; 30-feet pillars for 30-feet rooms, claiming to secure the safety of the rooms in the advance, and having pillars containing enough to insure their recovery, or attempt at recovery, when the rooms are worked out. We are apt to go from one extreme to another, and I am of the

opinion that a less width than this for pillars will be found more satisfactory.

Theoretically, nearly all admit, that is best to open the mine from the south-east corner, and drive entries to the further side of the property, and exhaust the coal in returning. Practically, the operator requires of his bank boss an output of coal as soon as he gets under cover, and is very restless under the necessary delays. Rooms are therefore laid out as soon as it is possible, and with narrow pillars between rooms, because more rooms can be opened on the same length of entry. These narrow pillars are liable to be crushed even before the rooms are worked out, and the consequence is that thereafter all the coal must be brought out through these old and dangerous workings, often requiring heavy expense for timbering to make them safe. As a specimen of this kind of mining ("and the woods are full of them"), I quote a case from Vol. V, Geology of Ohio:

"These mines, among others, illustrate the modes in which ultimate loss is incurred by unskillful management in mining. The coal of this field is easy of attack, and, at the outset, mines seem to have been located and worked with reference to immediate results, without definite and well-considered plans as to their coninuous operation. As a consequence, it has been found necessary already to shift, at large expense, tipples and tracks, while the underground workings present a dreary display of weakened and endangered entries, for which adequate protection can not now be easily secured, and a wilderness of lost pillars and props. Blocks of coal are also cut off occasionally from their natural routes of egress, and can be gained only by increased expense. The amount of coal needlessly sacrificed in the ——— mines by want of proper knowledge and skill in opening and managing them will reach a high figure. If this field had been from the first, handled with the same care and skill that characterize its recent management it would have made its present value greater by more than 200 acres of solid coal. In other words, more than 200 acres of coal have been needlessly lost to the field."

The double entry system of pillar and room, as I before remarked, is generally conceded to be the best of the plans now in use, but it does not follow that there may not be other systems as good or even better than this. But whatever system is adopted, a reliable and accurate record of workings should be kept, and I

think we should not be satisfied with any system, the working of which will not yield *ninety* (90) per cent of the coal. There are members of this Institute who are competent to give us something of value in regard to the proper methods of mining, and I hope they will make their views known at our next meeting. The members of the Institute are divided on the question of depth and width of rooms and the thickness of pillars, and I trust the advocates of the different plans will give us papers with the reasons of their views.

Another very important matter connected with exhaustive mining, in the question which possibly should have been asked at the beginning of this paper: What is minable coal? Mr. Roy, in his excellent chapter on coal mining, in Vol. V, Geology of Ohio, says that "All seams of coal two feet thick and upwards are regarded as the minable thickness, but four feet is regarded as the standard height. The expense attending the working of a three-feet vein is often considerably greater than working one four feet. exclusive of the dead work. This is a general but not universal rule, and obtains in mines like those of the Mahoning and Tuscarawas Valleys, where the coal varies suddenly in thickness. In such mines, for digging all coal below four feet, 5 cents per ton extra is paid for every 3 inches of decreasing height, until the seam falls to two feet, when it is regarded as unminable. At Leetonia, Hammondsville, and in the Coalton district of Jackson county, coals no thicker than 28 to 32 inches are wrought; but these coals possess peculiar qualities. The best coke in the State is made at Leetonia and Hammondsville, and everything that comes from the miner's pick is credited to him. At Coalton the coal is tender, and mines very easily. The difference in expense of mining a 4-feet coal over a seam 10 feet in thickness is inconsiderable in amount; the advantages to operators who possess thick coals consisting more in the greater yield per acre than the lessened cost of production. Thus, at Wellston, in Jackson county, the coal is 4 feet thick, while at Straitsville the bed is 9 to 10 feet thick, but the same price obtains in both places for digging; at Wellston the coal is a homogenous mass, while the thick coal of the Hocking Valley contains two bands of shale, and frequently a band of bone coal, which have to be sorted out by the miner, which militates considerably against his producing power."

The question of what is minable coal might better be answered

by saying it is a coal which it will pay to mine. If the coal is 10 feet in thickness and costs more to mine than can be obtained for it, it will be considered by the operator as not minable, while a coal 2 feet thick which will pay the operator a profit, would be considered as minable. The coal of the Hocking Valley is from 5 to 10 feet in thickness, and when it falls to four feet, as it sometimes does from a local fault, is by some considered too thin to work. If four feet is the standard height for the slate, as Mr. Roy says, it would seem that these parties are not justified in refusing to mine coal of that thickness, especially when we consider that the coal may rise again to its full height as we advance, even where it has fallen to a height less than four feet.

In exhaustive mining I assume it is the purpose to win *all* the coal. In the Hocking Valley our attention should not be confined to the Nelsonville seam alone. Lying above the Nelsonville seam is the No. 6 a, which is from 3 to 3½ feet thick; and still higher is the Bayley's Run coal, with a thickness of 4 to 6 feet. These seams are pronounced by Professor Orton as valuable, and being mined in other districts. They are spoken of as being especially excellent as steam coals, and possessing coking qualities which, if the sulphur can be eliminated by a process of washing, will make them of greater value than the Nelsonville seam. If these seams are not mined in advance of the Nelsonville seam, they will, for the most part, go to swell the immense amount of coal already wasted. The "long wall" system of mining, with wire rope hauling machinery, can certainly be used to great advantage in these seams, and, by reducing the cost of production, make them minable.

Mining operations in the past seem to have conducted upon the assumption that the supply of coal is inexhaustible. Let us see about the 47,000 acres in the Hocking Valley district. This area, at 6,000 tons per acre, would yield 282,000,000 tons. The C., H. V. & T. R'y has forwarded from the mines in this district since the opening of the road, the following amounts of coal in the years named:

	Tons.		Tons.
1870—	Not known.	1878—	913,864
1871—	302,766	1879—	1,108,792
1872—	604,881	1880—	1,230,337
1873—	806.872	1881—	1,453,197
1874—	485,076	1882—	1,801,686
1875—	752,970	1883—	1,901,726
1876—	782,283	1884—	1,056.202
1877—	800,795		

The above table shows a marked increase in the tonnage from year to year, and which, no doubt, will continue to increase. Calling the annnual output two millions tons, our field would be exhausted in one hundred and forty-one years, and if we consider the output of four millions tons annually—a not improbable assumption—the time would be only seventy years. While this may appear startling, it will be the fact, unless we adopt better methods of mining, and save these other coals which are now being so badly wasted.

Although I have confined my remarks to the Hocking Valley Region, I have no doubt they will fit other districts as well, and to the cry of the destruction of the forests will be added the destruction of the coal beds, and we will be held, in a measure, responsible for our bad management.

If he is a public benefactor who makes two blades of grass grow where one grew before, let us also give credit to him who will gain two tons of coal where only one has been secured in the past.